Fisheries

Potentials and Limitations of Life Cycle Assessment in Setting Ecolabelling Criteria: A Case Study of Thai Shrimp Aquaculture Product

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Abstract

Goal and Scope. The goal of this study is to explore the potentials and limitations of using LCA as the basis for setting ecolabelling criteria in developing countries. The practicality of using LCA for this purpose, as required by ISO 14020, has been criticised as lacking in transparency and scientific rigour. Furthermore, ecolabelling is not widespread in developing countries. The application of LCA has therefore been illustrated by using the specific case of shrimp aquaculture in Thailand, as a basis for ecolabelling criteria for a typical product intended for export from a developing country.

Method. For the LCA case study, the functional unit is the standard consumer-package size, containing 1.8 kg of frozen shrimp produced by conventional intensive aquaculture in Thailand, subject to an appropriate environmental management system. The impact assessment method used in this study is CML 2 Baseline 2000.

Results. According to the results from the LCA study, farming appears to be the key life cycle stage generating the most significant environmental impacts: abiotic depletion and global warming, which arise mainly from the use of energy; and eutrophication caused by wastewater discharged from the shrimp ponds. It is possible to cover these impacts by quantitative ecolabelling criteria. Other important impacts could not be quantified by the LCA: depletion of wild shrimp broodstock, impacts of trawling on marine biodiversity and the choice of suitable farm sites. These impacts, which are also related to the farming stage, must be covered by 'hurdle criteria'.

Conclusions and Recommendations. For the present case, LCA provides a basis for quantifying a number of important ecolabelling criteria related to the use of abiotic resources and to emissions. Other important issues, connected with the use of biotic natural resources and land, are not quantifiable by current LCA methodology, but were also revealed and clarified by using an LCA framework for the analysis. Thus, focussing the assessment on life cycle considerations, as required by ISO 14024, was effective in identifying all key environmental issues. In the light of this case study, main limitations and barriers associated with the application of LCA to setting ecolabelling criteria particularly in developing countries are discussed, including recommendations on how to overcome them.

Keywords: Ecolabelling; shrimp aquaculture; Thailand

Introduction

Ecolabelling is an approach, used worldwide in industrialised countries, as a way to promote more sustainable products in two complementary ways: by providing information enabling consumers to select purchases with the best environmental performance; and by 'benchmarking' environmental performance and thereby guiding product development (EC, 2000). According to the ISO 14020 series, the criteria for award of an ecolabel must be based on life cycle considerations. It is therefore logical to use Life Cycle Assessment (LCA) as a basis for developing ecolabelling criteria. However, LCA has been criticised for lack of transparency and scientific rigour (Lavallée and Plouffe 2004). Furthermore, neither ecolabelling nor the application of LCA to ecolabelling is well established in developing countries (Udo de Haes 2004). This article explores these issues through the application of LCA to ecolabelling using the specific case of a farmed shrimp product in a developing economy – Thailand. Farmed shrimp product is chosen for study in view of concerns over the associated environmental impacts, particularly from European consumers. Ecolabelling is seen in this context as a potential mode of environmental communication between producers and consumers. The choice of a food product is particularly relevant for this analysis, as many ecolabelling schemes, exemplified by the EU and Thai eco-labelling schemes, do not yet include these types of product. Even so, they are already covered by other labelling schemes like organic farming. The process of criteria setting involves three steps: assessment of relevant aspects, analysis of products on the market to identify whether these do differentiate on the identified aspects, and finally the setting of the criteria themselves. This article focuses on the first of these steps. In this study, a set of 'possible' environmental criteria that can be used for ecolabelling of a farmed shrimp product is presented. The potentials and limitations of using LCA for ecolabelling criteria setting have also been revealed, and recommendations are given on how to overcome these limitations. In addition, some of the difficulties in applying LCA in developing countries are discussed, including concerns over barriers to the ecolabelling of a typical product intended for export from a developing country.

1 Method

This study uses primary data collected in Thailand, to the maximum extent possible based on the shrimp production cycle in 2003[1]. These foreground data are supplemented by secondary data, for example describing the electricity supply system in Thailand, and by data from the Sima Pro database (version 5.1) where necessary. As a functional unit, a standard consumer package containing 1.8 kg of block-frozen shrimp is taken (plus 1.2 kg of ice, to a total package weight of 3 kg). This functional unit requires production of 3 kg of adult shrimp at the farm. The environmental impact categories assessed in this study are the standard LCA categories based on the CML 2 Baseline 2000 method (CML 2002): abiotic depletion potential (ADP), global warming potential (GWP), ozone layer depletion potential (ODP), human toxicity potential (HTP), freshwater toxicity potential (FTP), marine toxicity potential (MTP), photochemical oxidant formation potential (POCP), acidification potential (AP) and eutrophication potential (EP).

The LCA study covers the principal life cycle stages of the product system, which are:

i) **Capture of broodstock by demersal trawlers.** I.e. capture of shrimps which are ready to spawn to provide larvae to be cultured in hatcheries. Primary inventory data were collected for a trawler in Phuket province (South Western Thailand) which is one of the main areas of trawling for wild shrimp broodstock.

ii) **Culture of larvae in hatcheries.** Data were obtained from two hatcheries, representative of the main sources of post-larvae for farms. The hatcheries are respectively in Phuket province and Chacheongsoa province (Eastern Thailand). For both the hatchery and the farm (see below), data refer to the production period January to March.

iii) **Farming.** I.e. culture of post-larvae to adult shrimps by shrimp farmers. Data were obtained for a specific type of farm, being a 'Conventional and COC' farm in Chunthaburi province (Eastern Thailand). 'COC' denotes 'Code of Conduct for Responsible Marine Aquaculture', a set of environment management guidelines developed by the Department of Fisheries (DOF 2002). This represents conventional intensive aquaculture managed in accordance with the Code of Conduct.

iv) **Harvesting.** collection of adult shrimp at the farm. Corresponding to larvae culture and farming in January to March, data for harvesting refer to April and May.

v) **Sale and Transport.** purchase of adult shrimps at the farm by middlemen or brokers and transport to a central shrimp auction market.

vi) **Processing.** purchase of shrimp at central market, with transport to a plant for processing into block-frozen shrimp product. Data were collected for a processing plant in Samut Sakorn province (Central Thailand).

vii) **Transport overseas.** to the UK by ocean freighter.

viii) **Distribution.** via wholesalers to retail points by refrigerated truck.

ix) **Consumption.** food preparation in the home.

x) **Waste management.** of packaging and food residues plus sewage treatment.

[1] Full details of the LCA study are given by Mungkung (2005).

2 Results

According to the LCA results, farmed shrimp appears to contribute significantly to several impact categories and thus farming (stage iii) is identified as the key life cycle stage (**Fig. 1**). **Fig. 2** shows only the impacts of inputs and outputs from the farming stage for post-larvae produced from the Phuket

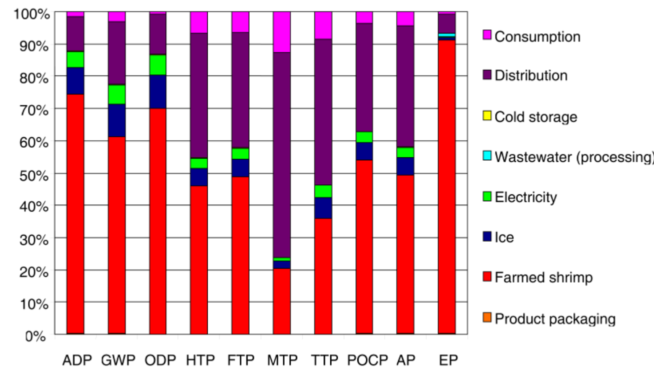

Fig. 1: Contributions to impacts associated with the life cycle production of one block-frozen shrimp, using the post-larvae from Phuket hatchery and the shrimps are farmed by Conventional & CoC (Note: the contributions from waste management and sewage treatment are too small to be discernible). Using the post-larvae from Chacheongsao hatchery also gave a similar trend

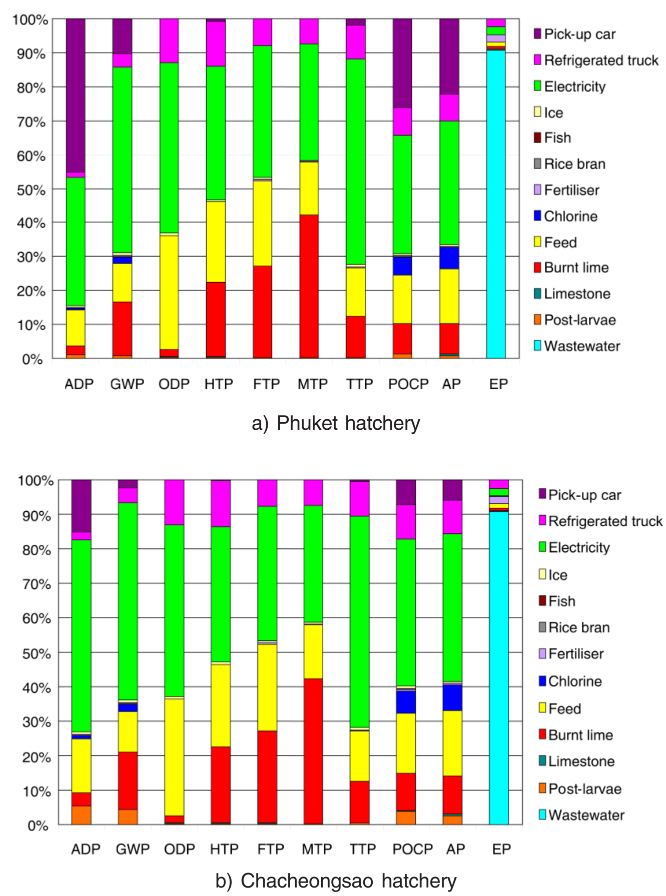

Fig. 2: Contributions to the environmental impacts of different life cycle stages for the shrimp produced by Conventional & CoC farm, using post-larvae from (a) Phuket and (b) Chacheongsao hatcheries

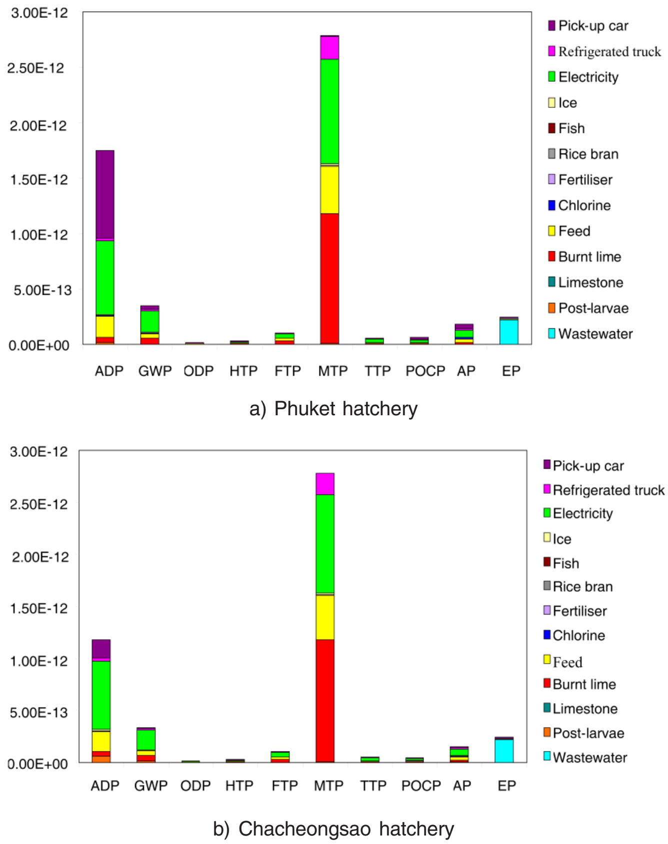

Fig. 3: Normalised LCA results for 1.8 kg of block-frozen shrimp, using post-larvae from (a) Phuket and (b) Chacheongsao hatcheries with shrimps produced by Conventional & CoC farm

and Chacheongsao hatcheries, respectively. The major contributors are the use of electricity, the use of shrimp feed, the use of burnt lime for neutralising the acid soil and water of the ponds, and the wastewater discharged from the shrimp pond. When the impacts in Fig. 2 are normalised (using global normalisation data, **Fig. 3**), the main environmental issues emerge as marine toxicity, abiotic depletion, global warming and eutrophication. Regarding marine toxicity, it is worth noting that the modelling of toxicity is associated with the assumptions made in the CML 2 baseline 2000 method in the SimaPro software: discounting has not been applied to future impacts (PRé Consultants 2003). This leads to very high impacts for persistent substances, especially metals, for which the life time is long, because the removal from the ocean is very slow.

To be more specific, the following major contributors to significant environmental impacts at the farm stage can be derived from the LCA study, in order of their severity:

- abiotic depletion as well as global warming from the diesel used by a trawler (to capture wild shrimp broodstock to supply the hatchery production system) and from the transport by refrigerated truck (to deliver the harvested shrimps from the farm to the central auction market); and from the use of electricity (for aeration systems and for the processing of the marine-caught fish into fishmeal, a major ingredient of shrimp feed);
- eutrophication due to high concentrations of nutrients in wastewater discharged from the shrimp pond.

Only stages (i) to (vi) fall within the scope of a product ecolabel, but stages (vii) to (x) were included to show whether they are responsible for any significant environmental impacts. Based on the LCA results in this study, farming is the stage to focus on in any development of an ecolabelling scheme. The significant environmental aspects identified from the LCA study as possible ecolabelling criteria for shrimp aquaculture products are:

Use of electricity and diesel oil. Electricity used for aeration systems and for the processing of the marine-caught fish into fishmeal (a major ingredient of shrimp feed) is a main contributor to several impact categories. Therefore, efficient use of electricity should be one of the important criteria for awarding an ecolabel, for instance the total energy used to produce 3 kg of adult shrimp (subsequently processed into one block of frozen shrimp). Further, the amount of diesel oil used by the trawlers could possibly be used as a criterion (see also under section 3, under domestic broodstock).

Organic and nutrient loading. Wastewater discharge from the shrimp pond potentially causes eutrophication due to the high concentration of nutrients as well as increased oxygen demand in the receiving water due to the high organic load. Organic and nutrient emissions are therefore possible criteria for ecolabelling.

Use of burnt lime. It is worth noting here that the high magnitude of marine toxicity as a result of using burnt lime is due mainly to emissions of metals during the production of burnt lime. Consequently, its application should be reduced and limestone should be used instead. However, the amount of burnt lime applied is strongly dependent on the particular environmental conditions of a farming site; thus it may well be considered as a possible local ecolabelling criterion (see Section 3).

3 Additional Relevant Impacts for Ecolabelling Criteria

In addition to the impacts derived quantitatively from the LCA study, a number of site-specific, often qualitative environmental impacts can also be important and should be considered as a possible basis for the setting of ecolabelling criteria (particularly of the so-called 'hurdle criteria', that is, criteria with a pass/fail character which all have to be met for award of an ecolabel). In the case of farmed shrimp, these additional impacts refer to biotic depletion (i.e. the depletion of wild shrimp broodstock), loss of biodiversity and impacts of land use.

Domesticated broodstock. Use of 'ready-to-spawn' broodstock can potentially cause the depletion of wild shrimp populations. In addition, trawling for wild broodstock can cause significant environmental impacts to marine ecosystems such as habitat destruction, trophic shift and biodiversity loss (RCEP 2004). Therefore, use of domesticated broodstock can possibly be used as a basis for an ecolabelling criterion, if technology for domesticated production of shrimp broodstock can be developed.

Use of marine-caught fish. Marine fish, i.e. by-catch from marine fisheries, is used in the form of fishmeal for shrimp feed production. This LCA study has shown that about 7.6 kg of marine-caught fish by trawler are required for production of 3 kg of farmed shrimp (i.e. 1.8 kg of frozen shrimp).

The utilisation of marine fish in the form of fishmeal is contentious in all forms of aquaculture due to the low efficiency of resource utilisation and to the impacts on marine biodiversity (RCEP, 2004). The seriousness and irreversibility of trawling effects on biodiversity of aquatic systems have also been highlighted by Thrane (2004). Therefore, the amount of fishmeal used in shrimp feed should be considered sufficiently important to be the basis for an ecolabelling criterion.

Farming site. To a certain degree, farm and pond management strategies are linked to the farming site. As indicated above, the amount of lime used is directly related to the soil and water properties of the site where the farm is located. Moreover, shrimp farms must not be constructed in sensitive areas, such as mangrove forests or freshwater areas; this is still practised, although it is illegal. Only farms that are located in areas suitable for shrimp farming, as identified by the Department of Fisheries or equivalent bodies in other countries, can qualify for an ecolabel, even if all other aspects are satisfied. Thus, the farm location should be considered as a basis for an ecolabelling criterion.

Sources of post-larvae. The LCA results have showed significant impacts associated with transport. In this respect, the distance between hatcheries and farming site is important and therefore the use of post-larvae from local hatcheries should also be considered as a basis for the setting of an ecolabelling criteria.

The identification of relevant environmental impacts for setting criteria for ecolabelling shrimp aquaculture products has been based on a Thai case study. In this case study, there were clear indications that the quantitative LCA-based impacts identified can be used to differentiate between the different shrimp products on the Thai market – which is relevant to step two in the process of setting ecolabelling criteria. Most probably this is also true for the qualitative impacts, for example, impacts on biodiversity will depend on the location of the farm, the type of farming systems and on pond management strategies applied. Thus the site-specific 'hurdle' criteria may well be different for different countries, depending on specific geographical and environmental conditions (Mungkung and Clift 2003). Accordingly, it is a challenge for criteria setting to make the criteria broadly applicable, sufficiently robust to accommodate variability in space and time, and still make them relevant and practically applicable.

4 Application of LCA to Ecolabelling in Developing Countries

This case study has shown that LCA can be used as an analytical tool in identifying environmental criteria for ecolabelling shrimp aquaculture products. On the other hand, some important criteria could not be quantified by LCA, particularly with respect to the local and site-dependent impacts. This implies that other tools are required to fill the gaps. Furthermore, LCA results are based on a wide range of assumptions in production and distribution systems, and this reduces the credibility of LCA results.

Apart from the limitations of LCA discussed above, the use of LCA also appears to be problematic especially in developing countries (Udo de Haes 2004). LCA is viewed as a resource- and time-intensive procedure. Limited knowledge in LCA and experience in its potential application is another barrier. Moreover, it is often the case that baseline data, especially describing background systems, are not always available in these countries and thus LCA practitioners have to supplement the missing data by using the databases provided in commercial LCA software, adding to the low confidence level of LCA results. Connected to this, the cost and time associated with the collection of inventory data along the entire life cycle are also seen as constraints to the use of LCA in developing countries.

There are also barriers connected to the use of ecolabelling as a product-oriented marketing tool. Presently, a major concern over ecolabelling is related to the different frameworks and criteria identified by different countries (Hes 2000). Producing countries are also confused over which labels are best for which markets (Clay 2004). The mutual recognition of ecolabelling schemes is another concern among producing countries. Furthermore, national ecolabelling schemes are strongly biased towards domestic industry standards, both intentionally and unintentionally (Piotrowski and Kratz 1999). All these aspects hinder the development and use of broadly accepted ecolabelling schemes.

Another issue of concern is that less modern technology, as often available in developing countries, may produce higher environmental impacts and, thus, cannot compete in markets of ecolabelled products. Moreover, some developing countries face difficulties in implementing ecolabelling programmes because they lack the necessary institutions and infrastructure (FIELD 2003). Thus, the gaps between developed and developing countries can generate discrimination effects and competitive disadvantages for the latter in an ecolabelling context (Deere 1999, KELA 2004). Also, part of the reluctance may arise from the lack of consumers' understanding of the message conveyed through ecolabels, and hence the lack of consumer acceptance of ecolabelled products. Participation in ecolabelling is also linked to the costs associated with the ecolabelling procedure including the maintaining of ecolabelling compliance. A premium price is expected as a consequence of labelling, but a higher price is not always realised for ecolabelled products.

5 Conclusions and Recommendations

The following conclusions can be drawn from the present study:

- A life cycle framework presents the best available basis for analysing a product's performance to identify key environmental issues in support of the development of ecolabelling criteria.
- Within this framework LCA proved to be successful in identifying and quantifying a number of significant environmental impacts related to the use of abiotic resources and emissions.
- This also can hold true for food products which usually are not included in ecolabelling schemes.

- A number of important local and site-specific impacts associated with biotic natural resources and land use could not be quantified by LCA; however, the use of the life cycle framework assisted in the identification a number of qualitative impacts which can constitute the basis for the setting of additional hurdle criteria.
- Lack of LCA expertise and financial resources as well as background data raise difficulties in developing countries in applying LCA for setting ecolabelling criteria.
- On the other hand, LCA results may reveal levels of technology used in production processes in developing countries which can generate a barrier to adoption of eco–labelling schemes.
- Neither the use of LCA nor Ecolabelling schemes should work as a barrier to trade; therefore costly technical and organisational measures should go together with a price premium for the products or otherwise be supported financially; this support should come from stakeholders in the industrialised countries, which provide the main drivers for the use of LCA and Ecolabelling.
- Product-information labels are still to be seen as an important means to introduce life cycle thinking into public consciousness, and to play an important role in promoting the move towards sustainable development.

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The Ecolabel and Sustainable Development

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Abstract

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The goal of the different national and supranational ecolabelling programs is to encourage consumers to choose products which are the least damaging to the environment. It is clear that the involvement of product and service users is essential to the establishment of sustainable consumption patterns. For this reason, ecolabelling must necessarily limit any risks of uncertainty. To this end, labels must take into account all the impacts of a product's life cycle and use a reliable and verifiable evaluation method.

In general, the organizations in charge of ecolabelling programs claim that a multi-criteria approach is used to define the exact labelling criteria appropriate for the product categories in question. These organizations generally maintain that their approach is based on the completion of exhaustive and complete life cycle analyses, which take into account all of the impacts caused by a product throughout its life cycle. And yet, the real situation is often far less clear-cut, and these simplified approaches, which tend to reconcile economic realism and methodological coherence, constitute the usual procedure for criteria definition.

Thus, the procedures involved in criteria development often rely on a 'semi-qualitative' approach to the life cycle which uses both qualitative and quantitative data in order to identify the product's significant stages on the environment.

Presently, the ecolabel is a 'non-verifiable expert property' for the consumer. The ecolabel's lack of objectivity in its criteria and its lack of transparency, resulting from non standardized methods whose accuracy cannot be measured, can only damage this sustainable development tool's credibility. In effect, the primary hindrance to ecolabel development lies precisely within this difficulty of finding a compromise between economic feasibility and the scientific and methodological rigor which are indispensable to the label's credibility and veracity.

Keywords: Ecolabel; environmental declarations; environmental labels